

F/G 9/1

DAAG29-77-6-0111

ML

ARO-14686.9-EL

20

END
DATE
FILMED
9-80
DTIC

12 AR 01 UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

AD A088075

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 14686.9-LL	2. GOVT ACCESSION NO. AD-A088 075 9	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) INVESTIGATION OF QUASI-OPTICAL INTEGRATED CIRCUITS AND ELECTROMAGNETIC SCATTERING AND RADIATION PROBLEMS.		5. TYPE OF REPORT, PERIOD COVERED Final Report 1 Mar 77-31 May 80
7. AUTHOR(s) 10 Raj Mittra		6. PERFORMING ORG. REPORT NUMBER 175
9. PERFORMING ORGANIZATION NAME AND ADDRESS University of Illinois Urbana, IL 61801		8. CONTRACT OR GRANT NUMBER(s) DAAG29-77-G-0111
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Research Office Post Office Box 12211 Research Triangle Park, NC 27709		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) 1271		12. REPORT DATE 11 Jul 80
		13. NUMBER OF PAGES 5
		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) NA		
18. SUPPLEMENTARY NOTES The view, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) waveguides electromagnetic scattering passive components electromagnetic radiation antennas millimeter waves integrated circuits		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) A brief summary of a three-year investigation of waveguides, passive components, active circuits and antennas for millimeter waves is presented. Research concentrated entirely on low loss, low cost and lightweight dielectrics that provide an alternate choice to metallic media which become lossy and expensive at millimeter wavelengths. The summary is supplemented by a complete listing of reports and journal publications resulting from the research.		

LEVEL

DTIC
ELIC
AUG 12 1980
A

DDC FILE COPY

408 102

INVESTIGATION OF QUASI-OPTICAL INTEGRATED CIRCUITS AND ELECTROMAGNETIC
SCATTERING AND RADIATION PROBLEMS

Final Report
for the period
1 March 1977 to 30 April 1980

Raj Mittra

July 1980

U. S. Army Research Office

Grant DAAG29-77-G0111

Electromagnetics Laboratory
Department of Electrical Engineering
Engineering Experiment Station
University of Illinois
Urbana, Illinois 61801

Approved for Public Release;
Distribution Unlimited.

Accession for	
ADAS Grant	<input checked="checked" type="checkbox"/>
ADAS	<input type="checkbox"/>
ADAS 1980	<input type="checkbox"/>
ADAS 1981	<input type="checkbox"/>
ADAS 1982	<input type="checkbox"/>
ADAS 1983	<input type="checkbox"/>
ADAS 1984	<input type="checkbox"/>
ADAS 1985	<input type="checkbox"/>
ADAS 1986	<input type="checkbox"/>
ADAS 1987	<input type="checkbox"/>
ADAS 1988	<input type="checkbox"/>
ADAS 1989	<input type="checkbox"/>
ADAS 1990	<input type="checkbox"/>
ADAS 1991	<input type="checkbox"/>
ADAS 1992	<input type="checkbox"/>
ADAS 1993	<input type="checkbox"/>
ADAS 1994	<input type="checkbox"/>
ADAS 1995	<input type="checkbox"/>
ADAS 1996	<input type="checkbox"/>
ADAS 1997	<input type="checkbox"/>
ADAS 1998	<input type="checkbox"/>
ADAS 1999	<input type="checkbox"/>
ADAS 2000	<input type="checkbox"/>
ADAS 2001	<input type="checkbox"/>
ADAS 2002	<input type="checkbox"/>
ADAS 2003	<input type="checkbox"/>
ADAS 2004	<input type="checkbox"/>
ADAS 2005	<input type="checkbox"/>
ADAS 2006	<input type="checkbox"/>
ADAS 2007	<input type="checkbox"/>
ADAS 2008	<input type="checkbox"/>
ADAS 2009	<input type="checkbox"/>
ADAS 2010	<input type="checkbox"/>
ADAS 2011	<input type="checkbox"/>
ADAS 2012	<input type="checkbox"/>
ADAS 2013	<input type="checkbox"/>
ADAS 2014	<input type="checkbox"/>
ADAS 2015	<input type="checkbox"/>
ADAS 2016	<input type="checkbox"/>
ADAS 2017	<input type="checkbox"/>
ADAS 2018	<input type="checkbox"/>
ADAS 2019	<input type="checkbox"/>
ADAS 2020	<input type="checkbox"/>
ADAS 2021	<input type="checkbox"/>
ADAS 2022	<input type="checkbox"/>
ADAS 2023	<input type="checkbox"/>
ADAS 2024	<input type="checkbox"/>
ADAS 2025	<input type="checkbox"/>
ADAS 2026	<input type="checkbox"/>
ADAS 2027	<input type="checkbox"/>
ADAS 2028	<input type="checkbox"/>
ADAS 2029	<input type="checkbox"/>
ADAS 2030	<input type="checkbox"/>
ADAS 2031	<input type="checkbox"/>
ADAS 2032	<input type="checkbox"/>
ADAS 2033	<input type="checkbox"/>
ADAS 2034	<input type="checkbox"/>
ADAS 2035	<input type="checkbox"/>
ADAS 2036	<input type="checkbox"/>
ADAS 2037	<input type="checkbox"/>
ADAS 2038	<input type="checkbox"/>
ADAS 2039	<input type="checkbox"/>
ADAS 2040	<input type="checkbox"/>
ADAS 2041	<input type="checkbox"/>
ADAS 2042	<input type="checkbox"/>
ADAS 2043	<input type="checkbox"/>
ADAS 2044	<input type="checkbox"/>
ADAS 2045	<input type="checkbox"/>
ADAS 2046	<input type="checkbox"/>
ADAS 2047	<input type="checkbox"/>
ADAS 2048	<input type="checkbox"/>
ADAS 2049	<input type="checkbox"/>
ADAS 2050	<input type="checkbox"/>
ADAS 2051	<input type="checkbox"/>
ADAS 2052	<input type="checkbox"/>
ADAS 2053	<input type="checkbox"/>
ADAS 2054	<input type="checkbox"/>
ADAS 2055	<input type="checkbox"/>
ADAS 2056	<input type="checkbox"/>
ADAS 2057	<input type="checkbox"/>
ADAS 2058	<input type="checkbox"/>
ADAS 2059	<input type="checkbox"/>
ADAS 2060	<input type="checkbox"/>
ADAS 2061	<input type="checkbox"/>
ADAS 2062	<input type="checkbox"/>
ADAS 2063	<input type="checkbox"/>
ADAS 2064	<input type="checkbox"/>
ADAS 2065	<input type="checkbox"/>
ADAS 2066	<input type="checkbox"/>
ADAS 2067	<input type="checkbox"/>
ADAS 2068	<input type="checkbox"/>
ADAS 2069	<input type="checkbox"/>
ADAS 2070	<input type="checkbox"/>
ADAS 2071	<input type="checkbox"/>
ADAS 2072	<input type="checkbox"/>
ADAS 2073	<input type="checkbox"/>
ADAS 2074	<input type="checkbox"/>
ADAS 2075	<input type="checkbox"/>
ADAS 2076	<input type="checkbox"/>
ADAS 2077	<input type="checkbox"/>
ADAS 2078	<input type="checkbox"/>
ADAS 2079	<input type="checkbox"/>
ADAS 2080	<input type="checkbox"/>
ADAS 2081	<input type="checkbox"/>
ADAS 2082	<input type="checkbox"/>
ADAS 2083	<input type="checkbox"/>
ADAS 2084	<input type="checkbox"/>
ADAS 2085	<input type="checkbox"/>
ADAS 2086	<input type="checkbox"/>
ADAS 2087	<input type="checkbox"/>
ADAS 2088	<input type="checkbox"/>
ADAS 2089	<input type="checkbox"/>
ADAS 2090	<input type="checkbox"/>
ADAS 2091	<input type="checkbox"/>
ADAS 2092	<input type="checkbox"/>
ADAS 2093	<input type="checkbox"/>
ADAS 2094	<input type="checkbox"/>
ADAS 2095	<input type="checkbox"/>
ADAS 2096	<input type="checkbox"/>
ADAS 2097	<input type="checkbox"/>
ADAS 2098	<input type="checkbox"/>
ADAS 2099	<input type="checkbox"/>
ADAS 2100	<input type="checkbox"/>
ADAS 2101	<input type="checkbox"/>
ADAS 2102	<input type="checkbox"/>
ADAS 2103	<input type="checkbox"/>
ADAS 2104	<input type="checkbox"/>
ADAS 2105	<input type="checkbox"/>
ADAS 2106	<input type="checkbox"/>
ADAS 2107	<input type="checkbox"/>
ADAS 2108	<input type="checkbox"/>
ADAS 2109	<input type="checkbox"/>
ADAS 2110	<input type="checkbox"/>
ADAS 2111	<input type="checkbox"/>
ADAS 2112	<input type="checkbox"/>
ADAS 2113	<input type="checkbox"/>
ADAS 2114	<input type="checkbox"/>
ADAS 2115	<input type="checkbox"/>
ADAS 2116	<input type="checkbox"/>
ADAS 2117	<input type="checkbox"/>
ADAS 2118	<input type="checkbox"/>
ADAS 2119	<input type="checkbox"/>
ADAS 2120	<input type="checkbox"/>
ADAS 2121	<input type="checkbox"/>
ADAS 2122	<input type="checkbox"/>
ADAS 2123	<input type="checkbox"/>
ADAS 2124	<input type="checkbox"/>
ADAS 2125	<input type="checkbox"/>
ADAS 2126	<input type="checkbox"/>
ADAS 2127	<input type="checkbox"/>
ADAS 2128	<input type="checkbox"/>
ADAS 2129	<input type="checkbox"/>
ADAS 2130	<input type="checkbox"/>
ADAS 2131	<input type="checkbox"/>
ADAS 2132	<input type="checkbox"/>
ADAS 2133	<input type="checkbox"/>
ADAS 2134	<input type="checkbox"/>
ADAS 2135	<input type="checkbox"/>
ADAS 2136	<input type="checkbox"/>
ADAS 2137	<input type="checkbox"/>
ADAS 2138	<input type="checkbox"/>
ADAS 2139	<input type="checkbox"/>
ADAS 2140	<input type="checkbox"/>
ADAS 2141	<input type="checkbox"/>
ADAS 2142	<input type="checkbox"/>
ADAS 2143	<input type="checkbox"/>
ADAS 2144	<input type="checkbox"/>
ADAS 2145	<input type="checkbox"/>
ADAS 2146	<input type="checkbox"/>
ADAS 2147	<input type="checkbox"/>
ADAS 2148	<input type="checkbox"/>
ADAS 2149	<input type="checkbox"/>
ADAS 2150	<input type="checkbox"/>
ADAS 2151	<input type="checkbox"/>
ADAS 2152	<input type="checkbox"/>
ADAS 2153	<input type="checkbox"/>
ADAS 2154	<input type="checkbox"/>
ADAS 2155	<input type="checkbox"/>
ADAS 2156	<input type="checkbox"/>
ADAS 2157	<input type="checkbox"/>
ADAS 2158	<input type="checkbox"/>
ADAS 2159	<input type="checkbox"/>
ADAS 2160	<input type="checkbox"/>
ADAS 2161	<input type="checkbox"/>
ADAS 2162	<input type="checkbox"/>
ADAS 2163	<input type="checkbox"/>
ADAS 2164	<input type="checkbox"/>
ADAS 2165	<input type="checkbox"/>
ADAS 2166	<input type="checkbox"/>
ADAS 2167	<input type="checkbox"/>
ADAS 2168	<input type="checkbox"/>
ADAS 2169	<input type="checkbox"/>
ADAS 2170	<input type="checkbox"/>
ADAS 2171	<input type="checkbox"/>
ADAS 2172	<input type="checkbox"/>
ADAS 2173	<input type="checkbox"/>
ADAS 2174	<input type="checkbox"/>
ADAS 2175	<input type="checkbox"/>
ADAS 2176	<input type="checkbox"/>
ADAS 2177	<input type="checkbox"/>
ADAS 2178	<input type="checkbox"/>
ADAS 2179	<input type="checkbox"/>
ADAS 2180	<input type="checkbox"/>
ADAS 2181	<input type="checkbox"/>
ADAS 2182	<input type="checkbox"/>
ADAS 2183	<input type="checkbox"/>
ADAS 2184	<input type="checkbox"/>
ADAS 2185	<input type="checkbox"/>
ADAS 2186	<input type="checkbox"/>
ADAS 2187	<input type="checkbox"/>
ADAS 2188	<input type="checkbox"/>
ADAS 2189	<input type="checkbox"/>
ADAS 2190	<input type="checkbox"/>
ADAS 2191	<input type="checkbox"/>
ADAS 2192	<input type="checkbox"/>
ADAS 2193	<input type="checkbox"/>
ADAS 2194	<input type="checkbox"/>
ADAS 2195	<input type="checkbox"/>
ADAS 2196	<input type="checkbox"/>
ADAS 2197	<input type="checkbox"/>
ADAS 2198	<input type="checkbox"/>
ADAS 2199	<input type="checkbox"/>
ADAS 2200	<input type="checkbox"/>
ADAS 2201	<input type="checkbox"/>
ADAS 2202	<input type="checkbox"/>
ADAS 2203	<input type="checkbox"/>
ADAS 2204	<input type="checkbox"/>
ADAS 2205	<input type="checkbox"/>
ADAS 2206	<input type="checkbox"/>
ADAS 2207	<input type="checkbox"/>
ADAS 2208	<input type="checkbox"/>
ADAS 2209	<input type="checkbox"/>
ADAS 2210	<input type="checkbox"/>
ADAS 2211	<input type="checkbox"/>
ADAS 2212	<input type="checkbox"/>
ADAS 2213	<input type="checkbox"/>
ADAS 2214	<input type="checkbox"/>
ADAS 2215	<input type="checkbox"/>
ADAS 2216	<input type="checkbox"/>
ADAS 2217	<input type="checkbox"/>
ADAS 2218	<input type="checkbox"/>
ADAS 2219	<input type="checkbox"/>
ADAS 2220	<input type="checkbox"/>
ADAS 2221	<input type="checkbox"/>
ADAS 2222	<input type="checkbox"/>
ADAS 2223	<input type="checkbox"/>
ADAS 2224	<input type="checkbox"/>
ADAS 2225	<input type="checkbox"/>
ADAS 2226	<input type="checkbox"/>
ADAS 2227	<input type="checkbox"/>
ADAS 2228	<input type="checkbox"/>
ADAS 2229	<input type="checkbox"/>
ADAS 2230	<input type="checkbox"/>
ADAS 2231	<input type="checkbox"/>
ADAS 2232	<input type="checkbox"/>
ADAS 2233	<input type="checkbox"/>
ADAS 2234	<input type="checkbox"/>
ADAS 2235	<input type="checkbox"/>
ADAS 2236	<input type="checkbox"/>
ADAS 2237	<input type="checkbox"/>
ADAS 2238	<input type="checkbox"/>
ADAS 2239	<input type="checkbox"/>
ADAS 2240	<input type="checkbox"/>
ADAS 2241	<input type="checkbox"/>
ADAS 2242	<input type="checkbox"/>
ADAS 2243	<input type="checkbox"/>
ADAS 2244	<input type="checkbox"/>
ADAS 2245	<input type="checkbox"/>
ADAS 2246	<input type="checkbox"/>
ADAS 2247	<input type="checkbox"/>
ADAS 2248	<input type="checkbox"/>
ADAS 2249	<input type="checkbox"/>
ADAS 2250	<input type="checkbox"/>
ADAS 2251	<input type="checkbox"/>
ADAS 2252	<input type="checkbox"/>
ADAS 2253	<input type="checkbox"/>
ADAS 2254	<input type="checkbox"/>
ADAS 2255	<input type="checkbox"/>
ADAS 2256	<input type="checkbox"/>
ADAS 2257	<input type="checkbox"/>
ADAS 2258	<input type="checkbox"/>
ADAS 2259	<input type="checkbox"/>
ADAS 2260	<input type="checkbox"/>
ADAS 2261	<input type="checkbox"/>
ADAS 2262	<input type="checkbox"/>
ADAS 2263	<input type="checkbox"/>
ADAS 2264	<input type="checkbox"/>
ADAS 2265	<input type="checkbox"/>
ADAS 2266	<input type="checkbox"/>
ADAS 2267	<input type="checkbox"/>
ADAS 2268	<input type="checkbox"/>
ADAS 2269	<input type="checkbox"/>
ADAS 2270	<input type="checkbox"/>
ADAS 2271	<input type="checkbox"/>
ADAS 2272	<input type="checkbox"/>
ADAS 2273	<input type="checkbox"/>
ADAS 2274	<input type="checkbox"/>
ADAS 2275	<input type="checkbox"/>
ADAS 2276	<input type="checkbox"/>
ADAS 2277	<input type="checkbox"/>
ADAS 2278	<input type="checkbox"/>
ADAS 2279	<input type="checkbox"/>
ADAS 2280	<input type="checkbox"/>
ADAS 2281	<input type="checkbox"/>
ADAS 2282	<input type="checkbox"/>
ADAS 2283	<input type="checkbox"/>
ADAS 2284	<input type="checkbox"/>
ADAS 2285	<input type="checkbox"/>
ADAS 2286	<input type="checkbox"/>
ADAS 2287	<input type="checkbox"/>
ADAS 2288	<input type="checkbox"/>
ADAS 2289	<input type="checkbox"/>
ADAS 2290	<input type="checkbox"/>
ADAS 2291	<input type="checkbox"/>
ADAS 2292	<input type="checkbox"/>
ADAS 2293	<input type="checkbox"/>
ADAS 2294	<input type="checkbox"/>
ADAS 2295	<input type="checkbox"/>
ADAS 2296	<input type="checkbox"/>
ADAS 2297	<input type="checkbox"/>
ADAS 2298	<input type="checkbox"/>
ADAS 2299	<input type="checkbox"/>
ADAS 2300	<input type="checkbox"/>
ADAS 2301	<input type="checkbox"/>
ADAS 2302	<input type="checkbox"/>
ADAS 2303	<input type="checkbox"/>
ADAS 2304	<input type="checkbox"/>
ADAS 2305	<input type="checkbox"/>
ADAS 2306	<input type="checkbox"/>
ADAS 2307	<input type="checkbox"/>
ADAS 2308	<input type="checkbox"/>
ADAS 2309	<input type="checkbox"/>
ADAS 2310	<input type="checkbox"/>
ADAS 2311	<input type="checkbox"/>
ADAS 2312	<input type="checkbox"/>
ADAS 2313	<input type="checkbox"/>
ADAS 2314	<input type="checkbox"/>
ADAS 2315	<input type="checkbox"/>
ADAS 2316	<input type="checkbox"/>
ADAS 2317	<input type="checkbox"/>
ADAS 2318	<input type="checkbox"/>
ADAS 2319	<input type="checkbox"/>
ADAS 2320	<input type="checkbox"/>
ADAS 2321	<input type="checkbox"/>
ADAS 2322	<input type="checkbox"/>
ADAS 2323	<input type="checkbox"/>
ADAS 2324	<input type="checkbox"/>
ADAS 2325	<input type="checkbox"/>
ADAS 2326	<input type="checkbox"/>
ADAS 2327	<input type="checkbox"/>
ADAS 2328	<input type="checkbox"/>
ADAS 2329	<input type="checkbox"/>
ADAS 2330	<input type="checkbox"/>
ADAS 2331	<input type="checkbox"/>
ADAS 2332	<input type="checkbox"/>
ADAS 2333	<input type="checkbox"/>
ADAS 2334	<input type="checkbox"/>
ADAS 2335	<input type="checkbox"/>
ADAS 2336	<input type="checkbox"/>
ADAS 2337	<input type="checkbox"/>
ADAS 2338	<input type="checkbox"/>
ADAS 2339	<input type="checkbox"/>
ADAS 2340	<input type="checkbox"/>
ADAS 2341	<input type="checkbox"/>
ADAS 2342	<input type="checkbox"/>
ADAS 2343	<input type="checkbox"/>
ADAS 2344	<input type="checkbox"/>
ADAS 2345	<input type="checkbox"/>
ADAS 2346	<input type="checkbox"/>
ADAS 2347	<input type="checkbox"/>
ADAS 2348	<input type="checkbox"/>
ADAS 2349	<input type="checkbox"/>
ADAS 2350	<input type="checkbox"/>
ADAS 2351	<input type="checkbox"/>
ADAS 2352	<input type="checkbox"/>
ADAS 2353	<input type="checkbox"/>
ADAS 2354	<input type="checkbox"/>
ADAS 2355	<input type="checkbox"/>
ADAS 2356	<input type="checkbox"/>
ADAS 2357	<input type="checkbox"/>
ADAS 2358	<input type="checkbox"/>
ADAS 2359	<input type="checkbox"/>
ADAS 2360	<input type="checkbox"/>
ADAS 2361	<input type="checkbox"/>
ADAS 2362	<input type="checkbox"/>
ADAS 2363	<input type="checkbox"/>
ADAS 2364	<input type="checkbox"/>
ADAS 2365	<input type="checkbox"/>
ADAS 2366	<input type="checkbox"/>
ADAS 2367	<input type="checkbox"/>
ADAS 2368	<input type="checkbox"/>
ADAS 2369	<input type="checkbox"/>
ADAS 2370	<input type="checkbox"/>
ADAS 2371	<input type="checkbox"/>
ADAS 2372	<input type="checkbox"/>
ADAS 2373	<input type="checkbox"/>
ADAS 2374	<input type="checkbox"/>
ADAS 2375	<input type="checkbox"/>
ADAS 2376	<input type="checkbox"/>
ADAS 2377	<input type="checkbox"/>
ADAS 2378	<input type="checkbox"/>
ADAS 2379	<input type="checkbox"/>
ADAS 2380	<input type="checkbox"/>
ADAS 2381	<input type="checkbox"/>
ADAS 2382	<input type="checkbox"/>
ADAS 2383	<input type="checkbox"/>
ADAS 2384	<input type="checkbox"/>
ADAS 2385	<input type="checkbox"/>
ADAS 2386	<input type="checkbox"/>
ADAS 2387	<input type="checkbox"/>
ADAS 2388	<input type="checkbox"/>
ADAS 2389	<input type="checkbox"/>
ADAS 2390	<input type="checkbox"/>
ADAS 2391	<input type="checkbox"/>
ADAS 2392	<input type="checkbox"/>
ADAS 2393	<input type="checkbox"/>
ADAS 2394	<input type="checkbox"/>
ADAS 2395	<input type="checkbox"/>
ADAS 2396	<input type="checkbox"/>
ADAS 2397	<input type="checkbox"/>
ADAS 2398	<input type="checkbox"/>
ADAS 2399	<input type="checkbox"/>
ADAS 2400	<input type="checkbox"/>
ADAS 2401	<input type="checkbox"/>
ADAS 2402	<input type="checkbox"/>
ADAS 2403	<input type="checkbox"/>
ADAS 2404	<input type="checkbox"/>
ADAS 2405	<input type="checkbox"/>
ADAS 2406	<input type="checkbox"/>
ADAS 2407	<input type="checkbox"/>
ADAS 2408	<input type="checkbox"/>
ADAS 2409	<input type="checkbox"/>
ADAS 2410	<input type="checkbox"/>
ADAS 2411	<input type="checkbox"/>
ADAS 2412	<input type="checkbox"/>
ADAS 2413	<input type="checkbox"/>
ADAS 2414	<input type="checkbox"/>
ADAS 2415	<input type="checkbox"/>
ADAS 2416	<input type="checkbox"/>
ADAS 2417	<input type="checkbox"/>
ADAS 2418	<input type="checkbox"/>
ADAS 2419	<input type="checkbox"/>
ADAS 2420	<input type="checkbox"/>
ADAS 2421	<input type="checkbox"/>
ADAS 2422	<input type="checkbox"/>
ADAS 2423	<input type="checkbox"/>
ADAS 2424	<input type="checkbox"/>
ADAS 2425	<input type="checkbox"/>
ADAS 2426	<input type="checkbox"/>
ADAS 2427	<input type="checkbox"/>
ADAS 2428	<input type="checkbox"/>
ADAS 2429	<input type="checkbox"/>
ADAS 2430	<input type="checkbox"/>
ADAS 2431	<input type="checkbox"/>
ADAS 2432	<input type="checkbox"/>
ADAS 2433	<input type="checkbox"/>
ADAS 2434	<input type="checkbox"/>
ADAS 2435	<input type="checkbox"/>
ADAS 2436	<input type="checkbox"/>
ADAS 2437	<input type="checkbox"/>
ADAS 2438	<input type="checkbox"/>
ADAS 2439	<input type="checkbox"/>
ADAS 2440	<input type="checkbox"/>
ADAS 2441	<input type="checkbox"/>
ADAS 2442	<input type="checkbox"/>
ADAS 2443	<input type="checkbox"/>
ADAS 2444	<input type="checkbox"/>
ADAS 2445	<input type="checkbox"/>
ADAS 2446	<input type="checkbox"/>
ADAS 2447	<input type="checkbox"/>
ADAS 2448	<input type="checkbox"/>
ADAS 2449	<input type="checkbox"/>
ADAS 2450	<input type="checkbox"/>
ADAS 2451	<input type="checkbox"/>
ADAS 2452	<input type="checkbox"/>
ADAS 2453	<input type="checkbox"/>
ADAS 2454	<input type="checkbox"/>
ADAS 2455	<input type="checkbox"/>

STATEMENT OF THE PROBLEM/SUMMARY

During the tenure of the grant in the last three years, we have been engaged in the investigation of waveguides, passive components, active circuits and antennas for millimeter waves. We have been concentrating entirely on low loss, low cost and lightweight dielectrics that provide an alternate choice to metallic media which become lossy and expensive at millimeter wavelengths.

We have investigated several different types of dielectric waveguides, e.g., the inverted strip and image guide, and have also studied various components derived from these waveguides. These structures have been investigated extensively both from the theoretical and experimental points of view. Two different approaches to analyzing dielectric waveguides have been developed. One of these is based on the mode matching technique which is applied in conjunction with the variational method. The second approach, developed more recently, employs the field expansion method as a first step, and is relatively more efficient as well as accurate. Extensive numerical results have been obtained using the field expansion method. These results have been compared against experimental measurements, and good agreement has been found. Comparison with results published elsewhere has revealed that the propagation constant predicted by the present technique agrees more closely with the experimental data than those derived using either the well-known effective dielectric constant of Toullos or the approximate methods of Goell and Marcatali, originally derived for planar waveguides.

One of the vexing problems in an open waveguide is the unwanted radiation from bends or other discontinuities which are invariably present in such components as couplers and resonators. We have investigated this problem and have designed a shield which reduces the radiation loss by as much as 7 to 8 dB thus making the loss due to radiation virtually negligible.

The shielded dielectric guide becomes an oversized, and hence overmoded, waveguide when the shield completely encloses the dielectric guide. Such a multimode guide may find useful application at frequencies above 100 GHz. We have developed analytical tools for investigating such waveguides.

A number of dielectric antenna configurations for millimeter wave applications have been designed and studied both theoretically and experimentally. Uniform or tapered dielectric rods, operating as surface wave antennas, radiate primarily in the endfire direction. When discontinuities, such as metal strips, are introduced in these rods, the primary mode of radiation changes to leaky wave type. We have successfully predicted some of the radiation characteristics, e.g., the direction of the main beam and the beamwidth, on a theoretical basis and have verified these predictions experimentally.

In addition to passive structures we have designed a number of active circuits, e.g., oscillators and mixers. We have addressed the problem of configuring open cavity designs that are compatible with dielectric waveguides. To date, we have built oscillators which have successfully operated up to 60 GHz. However, the designs themselves should be useful to 94 GHz range.

PERSONNEL

R. Mittra, Professor, Principal Investigator
V. L. Jamnejad, Research Associate
W. L. Ko, Research Associate
S. Kobayashi, Research Fellow (M.S. '80)
P. Parhami, Research Assistant (Ph.D. '80)
M. Tew, Research Fellow (Ph.D. '80)
N. Deo, Research Assistant (Ph.D. '80)
R. Lampe, Research Assistant
M. Desai, Research Assistant
S. Bhoosan, Research Assistant (M.S. '79)
J. McGuire, Research Assistant
R. Paleta, Research Assistant
P. Yang, Research Assistant (M.S. '77)
R. Rudokas, Research Assistant (M.S. '77)
L. Grun, Research Assistant (M.S. '77)

TECHNICAL REPORTS

1. M. Tew and R. Mittra, "Accuracy Tests for Asymptotic Solutions to Radiation From a Cylinder," Electromagnetics Lab Report No. 77-22, University of Illinois, October 1977.
2. P. Parhami, R. Mittra and Y. Rahmat-Samii, "Loaded Horizontal Antenna Over an Imperfect Ground," Electromagnetics Lab Report No. 77-25, University of Illinois, December 1977.
3. R. Mittra and P. Parhami, "Solving the Current Element Problem over Lossy Half-Space Without Sommerfeld Integration," Electromagnetics Report No. 78-14, University of Illinois, October 1978.
4. R. Mittra, Y. Hou and V. Jamnejad, "Analysis of Open Dielectric Waveguides Using Mode-Matching Techniques and Variations Methods," EM Report No. 79-8, University of Illinois, March 1979.
5. R. Mittra, S. Kobayashi, R. Lampe, S. Ray, "Dielectric Antennas for Millimeter-Wave Applications," Interim Technical Report for ARO, EM Lab Report 80-3, May 1980.

at/
7/80

JOURNAL PUBLICATIONS

1. William A. Davis and Raj Mittra, "A New Approach to the Thin Scatterer Problem Using the Hybrid Equations," IEEE Trans. on Antennas and Propagation, Vol. AP-25, No. 3, May 1977, pp. 402-406.
2. Y. Rahmat-Samii and Raj Mittra, "Spectral Domain Interpretation of High Frequency Diffraction Phenomena," IEEE Trans. on Antennas and Propagation, Vol. AP-25, No. 5, Sept. 1977, pp. 676-687.
3. R. Mittra and W. L. Ko, "An Approach to High-Frequency Scattering from Smooth Convex Surfaces," IEEE Trans. on Antennas and Propagation, Vol. AP-25, No. 6, November 1977, pp. 781-788.
4. Y. Rahmat-Samii and Raj Mittra, "On the Investigation of Diffracted Fields at the Shadow Boundaries of Staggered Parallel Plates -- A Spectral Domain Approach," Radio Science, Vol. 12, No. 5, Sept.-Oct. 1977, pp. 659-670.
5. P. Parhami, Y. Rahmat-Samii and R. Mittra, "A Technique for Calculating the Radiation and Scattering Characteristics of Antennas Mounted on a Finite Ground Plane," Proceedings IEEE, Vol. 124, No. 11, November 1977, pp. 1009-1016.
6. R. Mittra, "Spectral Domain Technique -- A Novel Approach for High Frequency Diffraction Problems," IRECON International Proceedings, Melbourne, Australia, 1977, pp. 75-77.
7. S. Safavi-Naini, S. W. Lee and R. Mittra, "Transmission of an EM Wave Through the Aperture of a Cylindrical Cavity," IEEE Transactions of Electromagnetic Compatibility, Vol. EMC-19, No. 2, May 1977, pp. 74-81.
8. C. M. Butler, Y. Rahmat-Samii and R. Mittra, "Electromagnetic Penetration Through Apertures in Conducting Surfaces," IEEE Trans., Vol. AP-26, No. 1, January 1978, pp. 82-93.
9. Y. Rahmat-Samii and R. Mittra, "Spectral Analysis of High-Frequency Diffraction of an Arbitrary Incident Field by a Half Plane -- Comparison with Four Asymptotic Techniques," Radio Science, Vol. 13, No. 1, Jan.-Feb. 1978, pp. 31-48.
10. Y. Rahmat-Samii, P. Parhami and R. Mittra, "Loaded Horizontal Antenna Over An Imperfect Ground," IEEE Trans. on Antennas and Propagation, Vol. AP-26, No. 6, Nov. 1978, pp. 789-796.
11. M. Tew and R. Mittra, "Accuracy Test for High Frequency Asymptotic Solutions," IEEE Trans. on Antennas and Propagation, Vol. AP-27, No. 1, January 1979, pp. 62-67.
12. R. Mittra, W. L. Ko and Y. Rahmat-Samii, "Solution of Electromagnetic Scattering and Radiation Problems Using a Spectral Domain Approach -- A Review," Wave Motion Journal, Vol. 1, No. 2, April 1979, pp. 95-106.

Journal Publications - continued

13. R. Mittra, R. Menendez, P. Yang, and N. Deo, "Effective Graded-Index Guides for Millimeter-Wave Applications," Microwave, Optics and Acoustics, Vol. 3, No. 2, March 1979.
14. R. Mittra and S. Safavi-Naini, "Source Radiation in the Presence of Smooth Convex Bodies," Radio Science, Vol. 14, No. 2, March-April 1979, pp. 217-237.
15. W. L. Ko and R. Mittra, "Modeling the X-Band Radar Augmentation Systems of a High Altitude Supersonic Target," IEEE Journal of Aerospace and Electronic Systems, Vol. AES-15, No. 3, May 1979, pp. 334-339.
16. R. Mittra, W. L. Ko and Y. Rahmat-Samii, "Transform Approach to Electromagnetic Scattering," Proceedings of the IEEE, Vol. 67, No. 11, November 1979, pp. 1486-1503.
17. R. Mittra and N. Deo, "Millimeter-Wave ICs Spring From the Lab," Microwaves, Vol. 18, No. 10, October 1979, pp. 38-42.
18. R. Mittra, P. Parhami and Y. Rahmat-Samii, "Solving the Current Element Problem Over Lossy Half-Space Without Sommerfeld Integrals," in IEEE Trans. on Antennas and Propagation, Vol. AP-27, No. 6, November 1979, pp. 778-782.
19. R. Mittra and N. Deo, "Integrate Antennas Into Planar Designs," in Microwaves, December 1979, pp. 60-64.
20. R. Mittra and N. Deo, "Dielectric-Based Active Components for Millimeter-Wave Integrated Circuits," in Military Electronics Defense Expo '79 CONFERENCE PROCEEDINGS, pp. 158-166.
21. R. Mittra and S. Bhooshan, "Multimode Waveguide Components for Millimeter-Wave Integrated Circuits," AEU, Band 34, 1980, pp. 27-29.
22. P. Parhami, R. Mittra and Y. Rahmat-Samii, "An Efficient Approach for Evaluating the Sommerfeld Integrals Encountered in the Problem of a Current Element Radiating Over Lossy Ground," in IEEE Trans. on Ant. and Propagation, Vol. AP-28, No. 1, January 1980, pp. 100-104.
23. R. Mittra, Y. Hou and V. Jamnejad, "Analysis of Open Dielectric Waveguides Using Mode-Matching Technique and Variational Methods," IEEE Trans. on Microwave Theory and Tech., Vol. MIT-28, No. 1, January 1980, pp. 36-43.
24. R. Mittra, "Recent Advances and Future Trends in Millimeter-Wave and Quasi-Optical Integrated Circuits," Proc. Intelcom '80, Rio de Janeiro, Brazil, May 1980, pp. 109-113.
25. P. Parhami and R. Mittra, "Wire Antennas Over a Lossy Half-Space," IEEE Trans. on Ant. and Prop., Vol. AP-28, No. 3, May 1980, pp. 397-403.